WHAT IS CLAIMED IS:

1. A method for staged assembly of a nanostructure comprising:

(a) contacting a surface-bound nanostructure intermediate comprising at least one unbound joining element with a solution comprising an assembly unit comprising a plurality of different joining elements, wherein:

(i) none of the joining elements of said plurality of different joining elements can interact with itself or with another joining element of said plurality,

(ii) a single joining element of said plurality can bind non-covalently to a single unbound joining element of the surface-bound nanostructure intermediate, and

(iii) the joining elements do not consist of or comprise T-even or T-even-like bacteriophage tail fiber proteins or binding fragments thereof;

(b) removing unbound assembly units; and

(c) repeating steps (a) and (b) to form a nanostructure.

2. The method of claim 1, wherein the surface-bound nanostructure intermediate consists essentially of an initiator assembly unit.

3. The method of claim 1, comprising the additional step of:

(d) capping the nanostructure with at least one capping unit.

4. The method of claim 1, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

5. The method of claim 1, wherein the assembly unit comprises at least one functional element.

6. The method of claim 4, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

7. The method of claim 1, wherein non-covalent binding is specific non-covalent binding.

8. The method of claim 7, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

9. The method of claim 4, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

10. The method of claim 1, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

11. The method of claim 4, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

12. The method of claim 5, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle, magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

13. The method of claim 1, wherein the joining element comprises a hapten, antigen, peptide, peptide epitope, PNA, DNA, RNA, aptamer, or polymer, or a binding derivative or binding fragment thereof.

14. The method of claim 13, wherein the peptide epitope is selected from the group consisting of SEQ ID NOS: 70-80.

15. The method of claim 4 wherein the structural element comprises a four-helix bundle.

16. The method of claim 4 wherein the structural element comprises a leucine zipper-type coiled coil domain.

17. The method of claim 16, wherein the leucine zipper-type coiled coil domain is selected from the group consisting of SEQ ID NOS: 1-69.

18. The method of claim 5, wherein a functional element is inserted between two leucine zipper-type coiled coil domains.

19. The method of claim 17, wherein the joining element is a hapten or a PNA.

20. A nanostructure assembly unit comprising a plurality of different joining elements, wherein:

(a) none of the joining elements of said plurality can interact with itself or with another joining element of said plurality;

(b) a single joining element of said plurality can bind non-covalently to a single unbound joining element of a surface-bound nanostructure intermediate; and

(c) the joining elements do not consist of or comprise T-even or T-even-like bacteriophage tail fiber proteins or binding fragments thereof.

21. The assembly unit of claim 20, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

22. The assembly unit of claim 20, wherein the assembly unit comprises at least one functional element.

23. The assembly unit of claim 21, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

24. The assembly unit of claim 21, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

25. The assembly unit of claim 21, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

26. The assembly unit of claim 20, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

27. The assembly unit of claim 26, wherein at least one of the plurality of assembly units is a capping unit.

28. The assembly unit of claim 21, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

29. The assembly unit of claim 22, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle, magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

30. The assembly unit of claim 20, wherein the joining element comprises a hapten, antigen, peptide, peptide epitope, PNA, DNA, RNA, aptamer, or polymer, or a binding derivative or binding fragment thereof.

31. The assembly unit of claim 30, wherein the peptide epitope is selected from the group consisting of SEQ ID NOS: 70-80.

32. The assembly unit of claim 21, wherein the structural element comprises a four-helix bundle.

33. The assembly unit of claim 21, wherein the structural element comprises a leucine zipper-type coiled coil domain.

34. The assembly unit of claim 33, wherein the leucine zipper-type coiled coil domain is selected from the group consisting of SEQ ID NOS: 1-69.

35. The assembly unit of claim 22, wherein a functional element is inserted between two leucine zipper-type coiled coil domains.

36. The assembly unit of claim 32, wherein the joining element is a hapten or a PNA.

37. The method of claim 1, wherein at least one joining element comprises a binding domain of an antibody or binding derivative or binding fragment thereof.

38. The method of claim 37, wherein the surface-bound nanostructure intermediate consists essentially of an initiator assembly unit.

39. The method of claim 37, comprising the additional step of:

(d) capping the nanostructure with at least one capping unit.

40. The method of claim 37, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

41. The method of claim 37, wherein the assembly unit comprises at least one functional element.

42. The method of claim 40, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

43. The method of claim 37, wherein non-covalent binding is specific non-covalent binding.

44. The method of claim 43, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

45. The method of claim 40, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

46. The method of claim 37, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

47. The method of claim 40, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

48. The method of claim 41, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle, magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

49. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a monoclonal antibody domain or binding derivative or binding fragment thereof.

50. The method of claim 49, wherein the monoclonal antibody domain is a humanized monoclonal antibody domain.

51. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises an IgG binding domain.

52. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a single-chain antibody domain or binding derivative or binding fragment thereof.

53. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a multispecific antibody domain or binding derivative or binding fragment thereof.

54. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a scFv.

55. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a Fv.

56. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a Fab.

57. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a $F(ab')_2$.

58. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a heterologous-$F(ab')_2$.

59. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a Fab-scFv fusion.

60. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a $F(ab')_2$-scFv fusion.

61. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a CDR of an IgG.

62. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of an scFv and a binding derivative of an IgG.

63. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of a cytokine and a binding derivative of an IgG.

64. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of a scFv and a leucine zipper.

65. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of a scFv and a Rop protein.

66. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a binding domain derived from a diabody.

67. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a binding domain derived from a triabody.

68. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a binding domain derived from a tetrabody.

69. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a multimeric scFv.

70. The method of claim 41, wherein the functional element is bound to a peptide region comprised in a binding derivative or binding fragment of an IgG.

71. The method of claim 41, wherein the functional element is bound to a peptide region comprised in a diabody or binding derivative or binding fragment thereof.

72. The method of claim 41, wherein the functional element is bound to a peptide region comprised in a triabody or binding derivative or binding fragment thereof.

73. The method of claim 41, wherein the functional element is bound to a peptide region comprised in a tetrabody or binding derivative or binding fragment thereof.

74. The method of claim 37, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises an idiotope.

75. The method of claim 74, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises an anti-idiotope directed against the idiotope.

76. The assembly unit of claim 20 wherein at least one joining element comprises a binding domain of an antibody or binding derivative or binding fragment thereof.

77. The assembly unit of claim 76, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

78. The assembly unit of claim 76, wherein the assembly unit comprises at least one functional element.

79. The assembly unit of claim 77, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

80. The assembly unit of claim 77, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

81. The assembly unit of claim 77, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

82. The assembly unit of claim 76, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

83. The assembly unit of claim 82, wherein at least one of the plurality of assembly units is a capping unit.

84. The assembly unit of claim 77, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

85. The assembly unit of claim 78, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle,

magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

86. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a monoclonal antibody domain or binding derivative or binding fragment thereof.

87. The assembly unit of claim 86, wherein the monoclonal antibody domain is a humanized monoclonal antibody domain.

88. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises an IgG binding domain.

89. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a single-chain antibody domain or binding derivative or binding fragment thereof.

90. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a multispecific antibody domain or binding derivative or binding fragment thereof.

91. The assembly unit of claim 76,wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a scFv.

92. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a Fv.

93. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a Fab.

94. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a $F(ab')_2$.

95. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a heterologous-$F(ab')_2$.

96. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a Fab-scFv fusion.

97. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a $F(ab')_2$-scFv fusion.

98. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a CDR of an IgG.

99. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of an scFv and a binding derivative of an IgG.

100. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of a cytokine and a binding derivative of an IgG.

101. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of a scFv and a leucine zipper.

102. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate is formed by a fusion of a scFv and a Rop protein.

103. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a binding domain derived from a diabody.

104. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a binding domain derived from a triabody.

105. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a binding domain derived from a tetrabody.

106. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a multimeric scFv.

107. The assembly unit of claim 78, wherein the functional element is bound to a peptide region comprised in a binding derivative or binding fragment of an IgG.

108. The assembly unit of claim 78,wherein the functional element is bound to a peptide region comprised in a diabody or binding derivative or binding fragment thereof.

109. The assembly unit of claim 78,wherein the functional element is bound to a peptide region comprised in a triabody or binding derivative or binding fragment thereof.

110. The assembly unit of claim 78,wherein the functional element is bound to a peptide region comprised in a tetrabody or binding derivative or binding fragment thereof.

111. The assembly unit of claim 76, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises an idiotope.

112. The assembly unit of claim 111, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises an anti-idiotope directed against the idiotope.

113. The method of claim 1 wherein at least one joining element comprises a pilin protein or binding derivative or binding fragment thereof.

114. The method of claim 113, wherein the surface-bound nanostructure intermediate consists essentially of an initiator assembly unit.

115. The method of claim 113, comprising the additional step of:

(d) capping the nanostructure with at least one capping unit.

116. The method of claim 113, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

117. The method of claim 113, wherein the assembly unit comprises at least one functional element.

118. The method of claim 116, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

119. The method of claim 113, wherein non-covalent binding is specific non-covalent binding.

120. The method of claim 119, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

121. The method of claim 116, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

122. The method of claim 113, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

123. The method of claim 116, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

124. The method of claim 117, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle, magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

125. The method of claim 113, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a pilin protein or binding derivative or binding fragment thereof.

126. The method of claim 125, wherein the pilin protein is selected from the group consisting of SEQ ID NOS: 81-90

127. The method of claim 125, wherein the pilin protein is a hybrid pilin protein.

128. The method of claim 127, wherein the hybrid pilin protein comprises an N-terminal extension sequence selected from the group consisting of SEQ ID NOS: 81, 83, 85, 87 and 89.

129. The method of claim 127, wherein the hybrid pilin protein comprises a pilin protein body sequence selected from the group consisting of SEQ ID NOS: 82, 84, 86, 88 and 90.

130. The method of claim 113, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a hybrid pilin protein, wherein the hybrid pilin protein comprises the pilin amino terminal extension of a first pilin protein and the pilin protein body of a second pilin protein and lacks the pilin protein body of the first pilin protein and the pilin amino terminal extension of the second pilin protein, wherein the amino terminal extension of the first pilin protein does not bind to the pilin protein body of the second pilin protein.

131. The method of claim 117, wherein the functional element is inserted at a peptide region comprised in a pilin protein or binding derivative or fragment thereof.

132. The assembly unit of claim 20 wherein at least one joining element comprises a pilin protein or binding derivative or binding fragment thereof.

133. The assembly unit of claim 132, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

134. The assembly unit of claim 132, wherein the assembly unit comprises at least one functional element.

135. The assembly unit of claim 133, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

136. The assembly unit of claim 133, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

137. The assembly unit of claim 133, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

138. The assembly unit of claim 132, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

139. The assembly unit of claim 138, wherein at least one of the plurality of assembly units is a capping unit.

140. The assembly unit of claim 133, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

141. The assembly unit of claim 134, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle, magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal

oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

142. The assembly unit of claim 132, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a pilin protein or binding derivative or binding fragment thereof.

143. The assembly unit of claim 142, wherein the pilin protein is selected from the group consisting of SEQ ID NOS: 81-90

144. The assembly unit of claim 142, wherein the pilin protein is a hybrid pilin protein.

145. The assembly unit of claim 142, wherein the hybrid pilin protein comprises an N-terminal extension sequence selected from the group consisting of SEQ ID NOS: 81, 83, 85, 87 and 89.

146. The assembly unit of claim 142, wherein the hybrid pilin protein comprises a pilin protein body sequence selected from the group consisting of SEQ ID NOS: 82, 84, 86, 88 and 90.

147. The assembly unit of claim 132, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a hybrid pilin protein, wherein the hybrid pilin protein comprises the pilin amino terminal extension of a first pilin protein and the pilin protein body of a second pilin protein and lacks the pilin protein body of the first pilin protein and the pilin amino terminal extension of the second pilin protein, wherein the amino terminal extension of the first pilin protein does not bind to the pilin protein body of the second pilin protein.

148. The assembly unit of claim 134, wherein the functional element is inserted at a peptide region comprised in a pilin protein or binding derivative or binding fragment thereof.

149. The method of claim 1, wherein at least one joining element comprises a peptide nucleic acid (hereinafter "PNA") or binding derivative thereof.

150. The method of claim 149, wherein the surface-bound nanostructure intermediate consists essentially of an initiator assembly unit.

151. The method of claim 149, comprising the additional step of:

(d) capping the nanostructure with at least one capping unit.

152. The method of claim 149, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

153. The method of claim 149, wherein the assembly unit comprises at least one functional element.

154. The method of claim 152, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

155. The method of claim 149, wherein non-covalent binding is specific non-covalent binding.

156. The method of claim 155, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

157. The method of claim 152, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

158. The method of claim 149, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

159. The method of claim 152, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

160. The method of claim 153, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle, magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

161. The method of claim 149, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a PNA or binding derivative thereof.

162. The method of claim 153, wherein the functional element comprises a sequence selected from the group consisting of SEQ ID NOS:158-180.

163. The method of claim 149, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a PNA or binding derivative thereof that is capable of dimerizing with another PNA or binding derivative via Watson-Crick or Hoogsteen base-pairing.

164. The method of claim 149, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a PNA or binding derivative thereof that is capable of dimerizing with another PNA or binding derivative thereof to form a triple-helical structure.

165. The assembly unit of claim 20 wherein at least one joining element comprises a PNA or a binding derivative thereof.

166. The assembly unit of claim 165, wherein the assembly unit comprises at least one structural element covalently linked to at least one joining element.

167. The assembly unit of claim 165, wherein the assembly unit comprises at least one functional element.

168. The assembly unit of claim 166, wherein the structural element is covalently linked to a first joining element and to a second joining element, and wherein the first and second joining elements cannot bind to each other.

169. The assembly unit of claim 166, wherein specific non-covalent interactions are stabilized post-assembly by conversion to covalent linkages.

170. The assembly unit of claim 166, wherein the assembly unit comprises a first structural element that is bound to a second structural element to form a stable complex, and wherein said first structural element is covalently linked to said at least one joining element.

171. The assembly unit of claim 165, wherein the assembly unit comprises a plurality of assembly units that bind to each other to form a stable complex.

172. The assembly unit of claim 171, wherein at least one of the plurality of assembly units is a capping unit.

173. The assembly unit of claim 166, wherein the assembly unit comprises at least one peptide segment disposed between the structural element and the joining element.

174. The assembly unit of claim 167, wherein the functional element comprises a photoactive molecule, photonic nanoparticle, inorganic ion, inorganic nanoparticle, magnetic ion, magnetic nanoparticle, electronic nanoparticle, metallic nanoparticle, metal oxide nanoparticle, gold nanoparticle, gold-coated nanoparticle, carbon nanotube, nanocrystal, nanowire, quantum dot, peptide, protein, protein domain, enzyme, hapten, antigen, biotin, digoxygenin, lectin, toxin, radioactive label, fluorophore, chromophore, or chemiluminescent molecule.

175. The assembly unit of claim 165, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a PNA or binding derivative thereof.

176. The assembly unit of claim 167, wherein the functional element comprises a sequence selected from the group consisting of SEQ ID NOS:158-180.

177. The assembly unit of claim 165, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a PNA or binding derivative thereof that is capable of dimerizing with another PNA or binding derivative via Watson-Crick or Hoogsteen base-pairing.

178. The assembly unit of claim 165, wherein a joining element of said plurality or an unbound joining element of the surface-bound nanostructure intermediate comprises a PNA or binding derivative thereof that is capable of dimerizing with another PNA or binding derivative thereof to form a triple-helical structure.